

**Title: Improved Tooling System**

The present invention relates to an improved component for use in a tooling system, and to an improved tooling system including this component.

5 The improved component is particularly suitable for use in the tooling systems described and claimed in International Patent Application No. WO 02/064308.

10 This patent application describes and claims a tooling system comprising a plurality of elements arranged in an array, each element being moveable longitudinally relative to the other elements in the array and having a first end, the system further comprising means to adjust the relative longitudinal positions of the elements such that the free ends of the elements define approximately a desired surface contour and means for retaining the elements in their adjusted positions, characterised in that: the first end of each element is provided on a machinable portion removably mounted to a base portion, the arrangement being such that the free ends of the elements can be machined to produce the desired surface contour.

15 This patent application further describes and claims a tooling system comprising a plurality of elements arranged in an array, the elements of the array being movable between a closed position in which the elements contact one another and are secured in position, and an open position in which the elements of the array are spaced apart and are capable of vertical movement relative to one another, and drive means for opening and closing the array. The  
20 elements are mounted on support rails to form the array.

In International Patent Application No. WO 02/064308, it is taught that the tooling system comprises means to adjust the relative longitudinal positions of the elements of the system.

Two alternative arrangements for adjusting the relative longitudinal positions of the elements are disclosed by way of example in International Patent Application No. WO 02/064308.

In one alternative arrangement, the elements are moved vertically relative to one another by a drive means comprising a downwardly extending threaded rod rotatably mounted to the underside of each element and threadingly engaged in a base portion. The elements are positioned by rotation of the threaded rods, each of which is driven by an electric motor.

- 5 In a second alternative arrangement, all of the elements are lifted manually and each element is allowed to fall under gravity to a desired position, when the element is secured.

It is an object of the present invention to provide a further alternative arrangement for moving the elements of an array of this type relative to one another, in order to increase the choice and options available to a user of the system.

- 10 It is a further object of the present invention to provide a component for use in this arrangement.

- The present invention provides a tooling system which comprises a plurality of elements arranged in an array, each element being supported on a cross rail and being moveable relative to the other elements in the array, characterised in that each element terminates in  
15 a threaded support post extending from a first end of the element, and is associated with a corresponding internally threaded aperture in the cross rail upon which the element is supported, and in that the tooling system further comprises an adjusting component in the form of a fork which is driveable in rotation and engageable with an element of the array to drive the element in rotation, upon rotation of the fork.

- 20 The radius described by rotation of the fork is preferably less than or equal to the radius of rotation of an element in the array.

- In a preferred embodiment of the tooling system according to the invention, the fork comprises a substantially square head portion, from each of the four corners of which square head depends a tine, the tines defining a gripping area corresponding to the area of an  
25 element of the array.

In a particularly preferred embodiment of the tooling system according to the invention, the fork comprises an adjustable fork, the tines of which depend from a head portion, the position of which tines can be adjusted relative to each other to define a plurality of differently sized adjustment areas.

- 5 In a further preferred embodiment of the tooling system according to the invention, the fork is connected to a driving means for driving the fork in rotation, by means of a flexible coupling.

The present invention further provides an adjusting component in the form of a fork for use in a tooling system of the type described above, which fork comprises a head portion, and  
10 a plurality of spaced tines depending from the head portion, each of which tines comprises a first section adjacent to the head portion and having an inwardly facing surface which together with the inwardly facing surfaces of the other tines defines an adjustment area and a second section remote from the head portion and having an inwardly facing guide surface.

The fork preferably comprises a square head portion, from each of the four corners of which  
15 depends a tine, each of the four tines comprising a first portion which is substantially triangular in cross-section, leading to a second portion, the inwardly facing surface of which tapers towards the free end of the tine.

The inwardly facing guide surface of the second section of the tine is preferably convex.

At the surface of the head portion from which the tines depend, the inwardly facing surfaces  
20 of the first sections of the tines define an adjustment area, the dimensions of which preferably correspond to the dimensions of the associated element of the array.

The first and second sections of the tine each preferably extends along the length of the tine to a distance which is greater than the maximum height variation in the machined surface of an element.

- 25 In a preferred embodiment of the fork according to the invention, the square head portion is

adjustable in size, so that the tines can be moved relative to one another to define a plurality of differently sized adjustment areas, corresponding to differently sized elements.

The tines of the fork are preferably further adapted to engage with an element of the array in gripping engagement, in order to enable the fork to lift the element after it has been rotated free of the support rail. Where the fork is itself adjustable, this gripping engagement may be effected by moving the tines away from the element and then pivoting them into engagement therewith. Alternatively, the tines may be formed with expandable faces.

The fork according to the invention preferably further comprises one or more sensors, for detecting the position of and measuring the force applied to an element of the array.

10 In a particularly preferred embodiment of the fork according to the invention, mass is added to the fork in order to increase its driving force.

The fork according to the invention is adapted to receive in driving engagement, a driving means for driving the fork in rotation.

15 An embodiment of a fork and a tooling system according to the invention will now be described with reference to the accompanying drawings, in which

Figure 1 is a view of a machine layout;

Figure 2 is a side view of a fork;

Figure 3 is a perspective view of the fork of Figure 2;

20 Figure 4 is a view of the fork of Figures 2 and 3 in driving engagement, with an element of the array of Figure 1;

Figure 5 is a view of an alternative embodiment of a fork, the size of which can be adjusted;

Figure 6 is a view of the fork of Figure 5, adjusted for gripping an element of the array and

Figure 7 is a view of a fork according to the invention connected by a flexible coupler.

As can be seen from Figure 1, a tooling system shown generally at 10 comprises a support table 2 on which is located a bridge 4, comprising a horizontal span 6 supported by first and second vertical supports 8,12. The horizontal span 6 supports an adjustment mechanism 14 and a machining tool 16.

The system 10 further comprises a consumable module 20 comprising array elements 24 supported on cross rails 22, which are themselves supported on a chassis (not shown) on the support table 2.

Each of the elements 24 terminates in a threaded support post 25 which engages with an internally threaded aperture (not shown) in the cross rail 22.

First and second side arms 26, 28 extend from the first and second vertical supports 8, 12 respectively, and terminate in retractable pegs 30, 32 adapted to engage with recesses in the ends of the cross rails 22.

The elements 24 are arranged in an array, as shown in Figure 4 and are held in place by four bolsters, two of which are shown at 34 and 36.

The machining tool shown generally at 16 comprises a spindle 42 and a tool head 44 mounted on the spindle 42.

The tool further comprises drive means (not shown) for locating and driving the tool head 44 via the spindle 42.

The adjusting mechanism shown generally at 14 comprises an adjustment fork 46 mounted on a spline and a pneumatic cylinder 48 and provided with a rotating drive (not shown).

As can be seen from Figures 2 and 3, the adjustment fork 46 comprises a square head portion 49 from which depend four tines 50, 52, 54 and 56, one tine depending from each of the four corners of the square head portion 49.

As can be seen from Figures 2, 3 and 4, each of the tines 50, 52, 54 and 56 comprise a first portion 58 which is substantially triangular in cross-section and which terminates in a tapered portion 60.

The tapered portion 60 provides an inwardly facing guide surface for the element 24. This inwardly facing guide surface has a convex profile.

In use, a target row of array elements 24 is selected and the consumable module 20 is driven, either manually or using a drive system, so that the target row is located parallel to the longitudinal axis of the bridge 4.

A section of the array including a row adjacent to the target row, and all of the rows of the array on the other side of that adjacent row, is separated from the target row, by first driving the bridge 4 into alignment with the adjacent row and then engaging the pegs 30, 32 in the recesses provided in the ends of the cross rail 22 supporting the adjacent row. The bridge 4 can then be used to separate the section from the target row.

The pegs 30, 32 are then retracted from the recesses in the cross rail 22 and the bridge 4 is then driven into alignment with the target row, and the pegs 30, 32 engaged in the recesses of the cross rail 22 supporting the target row. The target row can then be separated from the remaining adjacent row so that the elements of that row can be accessed.

An element within the target row is then selected. The adjustment mechanism 14 is then driven along the bridge 4 so that it is aligned vertically with a first element adjacent to the selected target element. The pressure in the pneumatic cylinder 48 is released and the fork 46 is allowed to fall under its own weight, so that the tines 50, 52, 54, 56 engage the head of the array element 24 in rotary driving engagement. As the fork 46 falls under its own weight, the guide surfaces of the tapered portions 60 operate to correct any misalignment of

the array element 24 by rotating it. The adjustment fork 46 is then driven in rotation through  $-45^\circ$  and the process is repeated with the second adjacent element.

The adjustment mechanism 14 is then aligned with the selected target element and allowed to engage the target element in a similar manner.

- 5 The adjustment fork 46 is then driven in rotation either to raise or lower the array element 24 by rotating it about the axis of its threaded post. When the element 24 has attained the predetermined height and correct angular orientation, the fork 46 is raised out of engagement with the element and is moved so that a next element is located beneath the adjustment fork and the adjustment process repeated until all of the array elements 24 in the line have been
- 10 adjusted to their predetermined heights. Fine correction of any misalignment of array elements may be carried out by lowering the fork into the open array, and using the external surfaces of the fork to align the array elements.

The tops of the array elements can then be machined as required using the machining tool 16.

- 15 An embodiment of an adjustable fork is shown in Figures 5 and 6. The adjustment sequence is shown in Figure 5, in which Figure 5(a) shows the tines defining an adjustment area corresponding to a first (smaller) element. The tines are then adjusted through an intermediate position Figure 5(b) to an extended position Figure 5(c) where the tines define an adjustment area corresponding to a second (larger) element.
- 20 The adjustable fork of Figure 5 is shown in Figure 6 in gripping engagement with an element of the array. The tines have been slightly extended away from the element and pivoted to grip the element.

An alternative means of connecting the fork to the driving means for driving the fork in rotation is shown in Figure 7.

- 25 A fork assembly shown generally at 710 comprises a fork having a head portion 702 from

which depend four times 704. The fork is connected by means of a flexible coupling 708 to  
a drive shaft 706. The figure shows the fork in two possible positions, Position 1 and Position  
2. The fork is naturally in Position 1, depending substantially vertically from the drive shaft  
706. As the fork is driven into engagement with an array element (not shown), any relative  
5 misalignment between the fork and the array element is compensated for by the flexible  
coupling 708, which allows the fork to take up a position, by way of example Position 2, in  
which it is able to engage the array element in gripping engagement.

The further operation of the fork of figure 7 is as described above for the alternative  
embodiments.

10 It will be appreciate that while a particular alternative position, Position 2, is shown in Figure  
7, this is merely by way of example and the actual position adopted by the fork depends upon  
the actual relative misalignment.